THE ANNALS

AND

MAGAZINE OF NATURAL HISTORY.

No. 106. NOVEMBER 1845.

XXXI.—*Anatomical and Physiological Observations on* Sagitta bipunctata. By M. A. Krohn*.

[With a Plate.]

The *Sagitta bipunctata* was first observed by MM. Quoy and Gaimard in the Straits of Gibraltar, at the commencement of their second voyage round the world†. Since that time the fauna of the Mediterranean Sea has been often explored and described by German and French naturalists; but, to my knowledge, none of these observers has again noticed this remarkable animal. It is extraordinary therefore, that last autumn and winter, during my stay at Messina, such a considerable number of these animals were to be met with, that I was sure, whenever the sea was calm, to perceive several carried along by the currents which prevail in those latitudes. This favourable circumstance enabled me very thoroughly to examine this animal, whose structure is still little known by zoologists.

The rapid sketch of the form and external parts of the *Sagitta*, given by MM. Quoy and Gaimard, was made from a young specimen four to five lines long. It is very conceivable that, from the small size of this specimen, several of its most important parts should have escaped the observers, and that they should have had but a vague apprehension of some other organs.

The body of the *Sagitta* is transparent as crystal, cylindrical,

* Translated from the Annales des Sciences Naturelles for Feb. 1845.

† Annales des Sciences Naturelles, 1st series, t. x. p. 232. I may also state here, that I am obliged to the kindness of Prof. Eschricht for the information that Mr. Scoresby met with an animal in the Arctic zone which has great analogy with the *S. bipunctata*, and which he has figured in his work (Account of the Arctic Regions, t. ii. pl. 16. fig. 1 & 2.). The reader will learn with pleasure that the researches of M. Eschricht on the *Sagitta* of the North, made in company with MM. Lovèn and Kröyer, are soon to be published.

almost regularly fusiform, growing narrow at its two extremities, but particularly at its posterior extremity. At the anterior extremity of the body a head is readily perceptible. Five projecting appendages then strike the eye of the observer, extended horizontally, and placed on the posterior half of the body: these appendages have the form of leaflets or fins, and give the animal, at first sight, some resemblance to a fish*. They are attached to the body by a widened base, and diminish gradually in thickness up to their margin, where they are very soft and flexible. The hindmost of these fins, that which embraces the posterior extremity of the body, is an odd one: the four others are arranged in pairs, that is to say, one opposite another, on each side of the body. The posterior fin is triangular, similar to the caudal fin of a fish, or rather, on account of its horizontal position, comparable to the terminal fin of the Cetacea. Each leaflet of the anterior pair of fins, placed almost in the middle of the body, has the form of a segment of a circle, whilst the two laminæ which constitute the following pair, longer and wider than the laminæ of the first pair, resemble, up to a certain point, a segment of a rhomb.

The head is manifestly isolated from the body, and surrounded by a kind of membranous hood, which the animal can draw back, and which it does in fact draw back when it seizes its prey. The upper surface of the head is placed on a level with the upper plane of the body; its lower surface, on the contrary, is oblique from above downwards and from before backwards. When the hood is in the state of the most complete expansion and brought over the head, the latter is entirely enveloped in it, with the exception of its under surface, in the middle of which is seen the mouth in the form of an elongated depression. When the animal draws back this hood, the head, and particularly its sides, are exposed, and the parts which I proceed to describe are perceived. In front and on each side there is a simple row of horny hooked prickles, arranged in a curved line, directed obliquely from above downwards and from before backwards (these are the *palpes striés* of MM. Quoy and Gaimard); they enable the animal to seize and bruise its prey. Their number varies in different individuals from five to seven on each side. They differ from one another in size; the upper or anterior hooks being most frequently shorter than the lower or posterior ones, which in their turn are shorter than the three or five middle hooks. They are very much flattened, but present a decided curve and a pointed end. The base by which they are attached to the skin

* For this reason the fishermen of Messina call this animal *Spadella*,—the diminutive of *spada*, a sword.

of the head is furnished at its edges with rather a broad ligula, but growing narrow as it rises. If the hood covers the head, and consequently the hooked spines, the latter, on both sides of the head, approach and touch one another at their points, which are turned towards the mouth. When the animal seizes its prey, these hooks, by a simultaneous retraction of the hood, first point upwards separating from one another, and are then lowered towards the object which the animal wishes to seize. Besides these spines, the head has two rounded prominences, situated on its anterior margin, and a simple series of very small, straight, sharp, and horny spines. Another similar series of spines is found on two ligulæ situated on two prominences on the under surface of the head. Nearly in the middle of the upper surface of the head, two very small oculiform, blackish points are observed, which have been already indicated by MM. Quoy and Gaimard.

It is well to remark here, that the apertures of the excretory canals, of the organs of generation and the anus are on the posterior half of the body. The animal is evidently hermaphrodite, for it possesses two ovaries, one on each side, and two cavities or cells in the posterior part of the abdomen or tail, and which serve for the secretion of the seminal fluid. The two apertures of the excretory ducts of the ovaries are at the base of the pair of intermediate fins, on the surface of the body, opposite to one another. Immediately in front of the base of the caudal fin there exists, on each side, a rounded and blackish prominence, which presents an aperture in the form of a fissure, directed obliquely from above downwards*. Each aperture, as we shall observe in detail further on, communicates with one of the seminal cavities above-mentioned, and assists in the secretion of the semen. The anus is situated nearly at the same height as the apertures of the excretory canals of the ovaries; but it is placed on the mesial ventral line of the body.

The length of the most developed individuals is nearly two inches and a half; the smallest which I have observed were about two lines and a half long; they were consequently only half the size of those observed by MM. Quoy and Gaimard. They resembled however, in all other respects, adult individuals.

This animal swims with great swiftness, and justifies the name which has been given it by the French naturalists. When it is touched after a long repose, it darts away suddenly with the rapidity of an arrow. During these movements, the fins appear to be wholly inactive. Indeed, from their structure, these parts do

* It is these two parts, these two blackish points, but not of this colour in all individuals, which have caused its specific name to be given to our *Sagitta*.

not seem adapted for swimming. Probably they facilitate the suspension of the animal in the water by increasing the extent of surface of the body.

I now proceed to consider the internal structure. I shall commence by that of the teguments and of the subjacent fibrous layer lying beneath : I shall then pass in review the organization of the three sections of the body, the head, trunk, and tail*. The study of the nervous system, followed by that of the eye, will conclude our remarks on this animal.

Teguments.—With the exception of the head, the skin is throughout, proportionally speaking, coriaceous and thick ; it is at the same time smooth, and scarcely loses its transparency. When immersed in spirits of wine, an epidermis appears to separate from it; it is completely homogeneous and presents no peculiar elementary tissue. On animals which have been kept for some time in alcohol, a great number of isolated, white, opake, and clearly circumscribed spots are discernible ; these are probably mucous follicles, more numerous and more pressed together on the anterior part of the trunk. On examining the internal surface of the skin, peculiar delineations, the nature of which I could not ascertain, are easily discernible with a moderate magnifying power. They are very clearly distinguishable on the lateral surfaces of the trunk, where, as I shall observe presently, there exists no subjacent muscular layer. With a higher power, these designs appear to traverse a number of fields, the outline of which is serrated in a zigzag manner by a large number of incisions, the denticulations of one space corresponding exactly to those of the adjoining, so that in no part can any void be perceived. At several points, very little extended, polygonal cells may be detected, often very regular, and presenting a central nucleus. Neither these cells nor the nuclei form any independent layer which can be isolated from the skin.

Fins.—As the fins are intimately blended at their base with the skin, the description of their structure will best follow here. They are formed, 1st, of a fundamental very transparent substance, which does not in the least become opake in spirits of wine, and presents no trace of either cells or fibres ; and 2ndly, of a peculiar envelope, of the elementary structure of which the microscope may furnish some indications. Even with the naked eye, loosened striæ in the form of rays, directed from the base to the margin of the fins, are distinguished; but, viewed thus, it is a very coarse image compared with that which it presents under the microscope. A number of very elongated, flexuous and delicate

* Every one will immediately understand that the division of the body into trunk and tail is arbitrary, and that the only advantage it has, is its being convenient and clear.

fascicles of fibres are perceived, advancing parallel to one another in the direction which I have indicated. These fibres, which, in their course from the base to the margin of the fin, become more and more slender as they advance, adhere so intimately to the fundamental substance, that they cannot be detached by any means, neither by compression nor by sliding one plate of glass over another, between which a fin had been previously placed. I must state here that these fibres in no manner resemble the muscular fibres.

Muscular layer.—The fascicles of muscular fibres, placed immediately beneath the skin, and which aid the animal's locomotion, form two bands extending the whole length of the body, but separated from each other by a considerable space. These two bands are placed opposite to one another; one on the dorsal surface, and the other on the ventral surface of the animal. Each of them however occupies a small portion of the two lateral surfaces. From the isolation of these bands, a considerable interval on each side results, where the skin is not furnished with a fleshy layer,—a circumstance which it is not easy to perceive in the living animal, on account of the transparency of all the tissues in their normal state, but which becomes evident after the muscular bands have been rendered turbid by their immersion in alcohol. The width of these muscular bands diminishes in the same proportion as the body recedes towards its two extremities. This is equally true for the intervals between them. To speak strictly, each band is resolved into two lateral halves, which remain closely connected with one another; so that the number of the muscular bands properly speaking is four. They are composed solely of fascicles of longitudinal fibres, arranged in several layers superposed and striated horizontally, like the primitive muscular fascicles of Insects and Crustacea. For this reason the animal is only capable of bending and extending the body; any diminution of the volume of the body in the direction of its transversal diameter is impossible. From what we have said respecting the direction of the muscular fascicles, it will be understood that all the motions from above downward, or from below upward, are effected by these animals with greater energy than the lateral motions. The observations of MM. Quoy and Gaimard perfectly agree with our own; for they have seen the *Sagitta*, whilst swimming, strike the water with its tail like a Cetacean.

I. *Head*:—*Hood*.—The hood is formed by the duplicature of the teguments of the head; the internal lamella appears to be more delicate than the external. Its insertion on the head follows the course of a line which, starting from the middle of the upper surface of the head, is directed a little behind its anterior margin. This line describes on each side a great curve, passing

round the base of the hooks outside and behind, in proceeding toward the lower surface of the head, behind the mouth. As we have already said, the hood only covers a portion of the head, leaving the lower surface almost completely exposed; the result is, that its lateral parts must be wider than its upper and lower portions. Between the two leaflets composing it we observe very evident slender fascicles of fibres, which have a parallel course to the outline; these fibres probably serve for the expansion of this part, whilst a simple mechanical action, the straightening of the hooks, and the swelling of the head, which is the consequence of it, casts back this organ.

Hooks.—These are composed of horny fibres, excessively delicate, and having a longitudinal direction. Their base is hollow, and contains a substance which becomes white and turbid in spirits of wine; it is probably a kind of bulb destined to regenerate the hook when this latter is worn or destroyed.

Muscular apparatus.—The principal mass of the head is composed of muscles arranged symmetrically on the two sides of the head; the most voluminous among them are those which form its base, and on this account, these masses, seen in profile, appear to be obliquely truncated; in fact, each of them constitutes the corresponding half of the head. When they are in action, raising the hooks, they form two considerable eminences which project beyond the two prominences which surround the mouth. They are resolved into numerous fascicles, the direction of which it is difficult to detect. We know however positively that most of these fascicles are inserted at the base of the hooks, and others on to a thin and hard plate, which I must here describe. This plate exists on each side, immediately beneath the skin. It extends on the surface of the muscles in question, at first between the bases of the hooks and the points of insertion of the hood; it then forms a curve, following this insertion as far as the anterior margin of the head; and lastly, growing thinner, enters into the eminences which bear the little spines abovementioned.

With regard to the other pairs of muscles, I confess that I have not been able to follow them in a satisfactory manner; their minuteness baffled my patience; and if I were able to indicate the origin and insertion of some of them, I should still find it impossible to explain their action.

Pharynx.—The pharynx is a short duct, situated in the middle of the head, and only a little wider than the stomachal swelling. Laterally, it is limited by the two muscles of the hooks, and, as it seems also, by walls furnished with very decided muscular fibres, crossing one another.

II. *Trunk.*—The cavity of the trunk is filled, during the life

of the animal, with a soft, translucid, apparently mucous substance, which is coagulated and rendered flocculent by the addition of alcohol; it contains no other organs than the stomachal swelling and the ovaries; it is isolated, as well from the head as from the tail, by transversal partitions.

The *stomachal swelling* is a somewhat considerable canal, which extends through the whole length of the cavity of the trunk; it is a little compressed laterally, but its width is throughout the same. After having reached the last transversal partition, it there describes a small curve, taking a direction toward the anus, and during this short passage it becomes funnel-shaped. It is difficult to detect the structure of its walls, and what I shall here advance must not be regarded as proved. These walls appear to be composed of three layers. The outer one is formed of excessively minute annular fibres, close together, and readily detected under a high magnifying power. I have only been able to distinguish longitudinal fibres in two limited spots, that is to say, only on the central line of the walls. They form, in fact, upon the upper central line, as well as on the lower line, two filaments isolated from one another throughout the extent of the stomachal swelling, and are placed exteriorly to the annular fibres. The central layer is formed of polygonal cellular spaces, above or beneath which is perceived a number of round bodies, produced by the union of very small and nowise polygonal cellules. These are apparently glands, which, perhaps, are destined to secrete the liquid necessary for digestion. The internal layer is a homogeneous epithelium, furnished with long and thin cilia possessed of a lively vibratory motion. Above, the stomachal swelling is attached by a simple ligament, tolerably resisting, extending throughout its length, to the upper wall of the cavity of the trunk; inferiorly, numerous slender fibrous filaments are perceived, mostly ramified, attached to the wall opposite to the cavity of the trunk, and which are fixed to the stomachal swelling, on the other side of the superior ligament. I have often taken these last for vessels. On this point, as I shall not return to it, I may observe that I have never been able to distinguish the least trace of a vascular system. The observation of very young individuals, under a convenient magnifying power, has furnished me with no result in this respect, any more than the dissection of larger individuals; but I do not intend by this to affirm that there is a complete absence of the vascular system.

Most frequently the stomachal swelling is found in a state apparently quite empty; I have only observed it to be filled with solid nutritive matter, such as fragments of small fishes and crustacea, in a few instances. When several of these animals were

kept in the same vessel, I rarely remarked that they devoured one another, or that they were inclined to do so.

The *ovaries* have been already described by MM. Quoy and Gaimard. Each ovary is a pouch terminated anteriorly in a cæcum, and fixed by a slender ligament to the inferior wall of the cavity of the trunk; it extends in a straight line from anteriorly backwards, parallel to the corresponding margin of the inferior muscular band, and lastly forms a loop, on rising towards the dorsal surface of the animal. There it opens exteriorly between the upper muscular band and the base of the last fin. I fancied that I perceived in the sides of the ovarian pouch, under a strong magnifier, thin fibres, which, where the germs of ova (*stroma*) occurred, appeared to form two interlaced layers. The stroma, which may be detected throughout the whole length of each ovarian pouch, only exists in the half of this organ, in relation with the ligament.

The length and the width of the ovaries, very variable according to the age of the individuals, are in direct relation, as may easily be conceived, to the number and development of the eggs contained in them. In individuals of two lines and a half in length, only feeble rudiments of them are seen; the ovules are then extremely small. These ovaries increase more and more in length and breadth up to the adult age, that is to say, up to the moment of coition, at which period they are seen to project above the first pair of fins*. All the eggs, the smallest as well as the largest, exhibit a germinal vesicle; but no circumscribed germinal spot can be discovered in them. The vesicle appears of a relatively very considerable volume in the youngest ovules; it increases at first a little in size in proportion as the vitellus diminishes; but it remains at length stationary,—relations which exist in all known animals. When we examine very developed ovaries, we find that the youngest ovules are appended to the stroma by a short pedicel, whilst the most advanced ovules, which are surrounded by a very visible chorion, are not provided with this pedicel.

III. *Tail:—Seminal cells.*—The cavity of the tail is divided throughout its length by a vertical partition attached to the transversal septum, which limits posteriorly the cavity of the trunk, and is thus divided into two cells perfectly independent of one another. It is in these cells, as we have already stated, that

* There are however exceptions to this rule: the ovaries are sometimes less developed in the large individuals than in other smaller ones. I remember in particular an individual the length of which was only three-quarters that of a normal adult, and in which the fecundation nevertheless took place in the interior of the ovaries, which were highly developed.

the seminal fluid is elaborated. The *Sagitta* therefore presents no seminal gland organized in the manner of a testicle.

The apparatus destined to contain and to convey the mature seminal fluid is very singular. It is already known that each cell opens exteriorly, before the caudal fin, by an aperture situated on a rounded prominence. This prominence is excavated and communicates with a canal hollowed in the thickness of the skin of the tail, and which goes finally into the cell of the corresponding side. In fact, if we open each cell inferiorly, by a longitudinal section, and examine the interior surface of the upper wall thus exposed, after having removed with the greatest care all the viscous matter, we distinctly observe, with a magnifying power of ten to twelve diameters, that at a small distance from each prominence there is a rounded aperture with swelled margins. This cavity leads into the canal above-mentioned, which extends posteriorly, following the margin of the upper muscular band, and describing a slight curve. At first somewhat broad, it gradually becomes more and more narrow, and opens into the cavity of the prominence. This cavity is relatively very large, and appears, for this reason, to serve to collect and preserve the seminal fluid, before its final exit. The internal sides of the two excretory canals, and the apertures with swelled sacculated margins are covered with a fine membrane furnished with very numerous long cilia close together and very vibratory.

Seminal fluid.—The mature fluid is of a chalky-white colour, thick, and formed solely of spermatozoids. It is often found on the external aperture of the seminal cells in the form of flakes or drops. When one of these drops is observed with the microscope, the phænomenon known by the name of total movement of the seminal mass is instantly observed. The spermatozoa are capilliform, much elongated, and evidently narrowed toward their two extremities, where they are pointed; they have an undulatory or serpentine movement.

The results of my researches on the development of these bodies are very limited; I believe however that they agree generally with those of Dr. Kœlliker on certain Annelides, and in particular on the *Branchiobdella parasita* or *Pontobdella spinosa*. [See his memoir entitled "Beiträge zur Kenntniss der Geschlechtsverhältnisse und der Samen-flussigkeit wirbellosen Thiere," pp. 18 and 24.] In all the individuals except those in which the period of fecundation is near, and even in those which are only two lines and a half long, bodies resulting from the agglomeration of a great number of vesicles, or of small and spherical cells, are perceived in the limpid seminal fluid; these are the bodies known by the name of aggregations of cells (*Zellenhaufen*), or by the still more recent name of seminal globules (*Samenkugeln*): it is in these

aggregations that the spermatozoa are subsequently developed. Their size varies in the different individuals, and they are more numerous in proportion as they are younger. In the greater number of individuals, below or little above the mean size, only these aggregations of cells are met with; when the animals increase in size their number visibly diminishes, by their transformation into spermatozoa. Lastly, the seminal cells of the adult individuals contain, shortly before fecundation, only spermatozoa. The cells which compose the seminal globules are all of the same size, do not adhere together by any apparent means of union, and contain numerous small granules, rarely a voluminous nucleus, which is immediately rendered perceptible by the addition of dilute acetic acid; by this means also the sides of the cells containing them become visible. The spermatozoa, which, as I have already stated, become more numerous in proportion as the animal is developed, appear under a variety of forms. Sometimes they are bodies split in their middle into two prolongations or tails, more or less long, following the same direction, receding more and more, terminating in a point and forming amongst themselves an angle more or less open; at other times these tails extend in a straight line; at others again a third tail is added, which is directed laterally, starting from the middle part, &c. The result of an attentive examination is, that these varied forms may be attributed to the differences which each of the successive phases of development presents: thus we see a great number of very small tails developed upon a seminal globule, which may be compared to spurs; these prolongations, the first rudiments of the spermatozoa, already exhibit, at their base, traces of organization at its commencement, which extends more and more, becomes general, and advances in the same proportion as the volume of the spermatozoon increases. During these metamorphoses, the primordial cells are very considerably modified; they become smaller, lose their granular contents, and, at a certain period, appear only as simple appendages,—filaments: these are the spermatozoa in the process of formation. The masses formed principally of spermatozoa in the mature state are easily distinguished by their intensely white colour, whilst the masses of less-developed spermatozoa may be recognised by their faint white aspect. Probably the spermatozoa become disaggregated at the period of their maturity; then, being free, they pass into the excretory canals, and, propelled by the currents produced by the movements of the vibratory cilia, they finally reach the hollow prominences.

I should here mention a very remarkable phænomenon which occurs in the interior of the seminal cells. This consists in slow, very manifest movements of the seminal globules and masses of spermatozoa, which take place in a greater or less extent, and

which are frequently effected by a sort of rotation, and resemble a true circulation. In fact, in this latter case, one or several of these bodies progress along one of the sides of the seminal cell, then pass to the opposite side of the same cell, proceed along it in a direction reverse to the first, and so on. [This circulation is far more active and more general in individuals less developed.] In other cases these bodies have very little motion, being sometimes attracted and sometimes repulsed by the walls. Frequently indeed the majority of these bodies remain immoveable, until, at a given moment, each begins to move, as if its turn had arrived. Generally these movements do not extend beyond the posterior part of the seminal cells. The cause of this phænomenon is due to the existence of very minute and at the same time very transparent vibratile cilia on the posterior wall of the cells, and which by their motion produce currents in the seminal fluid.

The seminal globules move also in the same manner in the testicular vesicle of the leech, that is to say, describing a continual circle along the sides of that vesicle. Professor Henle observed it several years ago (see his observations on the *Branchiobdella* in the 'Archives' of Müller for 1835, p. 586), and recently, in speaking of the same phænomenon in his beautiful work on the tissues of animals (Allgem. Anatom. p. 211), he states that the cause of it is not well known. But, in all probability, this rotation is equally produced by these vibratory cilia.

The maturation of the seminal fluid advances in each individual parallel to that of the eggs, which might be presumed from what has been said on these two products. In a young or in an adult animal, the products of the male and female generative organs are always at an equally advanced period of their development. The result of this is, that at a determined period, the ova and the seminal fluid have acquired a simultaneous maturity, and that the fecundating fluid is introduced into the ovarian pouch. In fact, in certain individuals the fecundation is already effected. Their ovaries, filled with a great number of very large eggs, which extend from two to three lines below the first pair of fins, contain, at the side of the ova, a considerable quantity of seminal fluid, the spermatozoa of which exhibit very lively movements, as is indeed the case with those of other animals at the rutting period.

The question still remains to be ascertained, whether the *Sagittæ* fecundate mutually, or whether they are androgynous. With respect to this point, I must attribute great weight to a constant phænomenon which strikes us when we examine the individuals in question. In fact, the seminal cells in them are constantly empty, without any trace of spermatozoa, which were before so numerous, or at least only a very small number are found, almost

all in their state of maturity. According to this, it is scarcely doubtful that the seminal fluid introduced into the ovarian cavities belongs to them, and that, consequently, the *Sagitta* fecundates itself. But by what means is the seminal fluid transferred from the male into the female apertures, and how does it pass over so great a space? It is difficult to say; I can only offer presumptions on this point. If we suppose that the water serves as the vehicle, we are scarcely more advanced, as it is necessary to explain how the seminal fluid is conducted into the ovary. Shall we admit that it is propelled by currents produced by the movements of the vibratory cilia, existing either toward the entrance into the ovaries or at the mouth of their excretory ducts? But I have never been able to perceive, in any part, these vibratory cilia in the female genital apparatus. It is therefore probable that the transference of the seminal fluid is effected by the alternate approach of the male and female apertures; and this may take place by means of the tail being curved under the body.

Nervous system:—Cephalic ganglion.—The principal ganglion of the head, or the cephalic ganglion properly so called, is situated in the middle of the upper surface of the head and at a short distance from its anterior margin, immediately beneath the skin and above the pharynx. It is flattened, nearly hexagonal, and, in adult individuals, it is about a quarter of a millimetre in extent. It sends out two pairs of nerves, one anterior, one posterior, and communicates with the trunk or ventral ganglion by two strong and elongated œsophagian commissures.

Each of the anterior cephalic nerves is detached from the anterior margin of the ganglion, remains at first almost parallel to its congener, is then directed toward the prominence furnished with bristles already mentioned, penetrates into the fascicles of some muscles, and finally loses itself in the muscle of the hooks of the corresponding side, after having become swelled into a kind of ganglion, in the vicinity of this muscle. From this swelling several filaments radiate, which divide themselves in the muscle.

The two posterior cephalic nerves, which spring from the posterior margin of the ganglion, exhibit remarkable peculiarities. They are larger and more elongated than the anterior ones, remain, throughout their course, just beneath the skin of the upper surface of the head, and extend to the limits of the trunk. They diverge considerably from their very commencement, and curve finally into a circle toward the median line of the head, where they anastomose, forming a kind of nervous arcade. At a little distance from their origin, each of these small trunks furnishes an optic nerve, which will be considered hereafter.

Ventral ganglion.—This ganglion is situated in the middle of

the ventral surface of the trunk, and like the preceding one, just beneath the skin; it must be sought for between the head and the first pair of fins, but nearer to the latter. It is ovoid, elongated, swollen, and in adult individuals is nearly a millimetre and a half long. It consists of a medullary substance or intense white nucleus, and of a cortical layer of a fainter white. This last layer is composed of a multitude of ganglionic globules. This nerve furnishes four principal branches, which, in their course, proceed along the ventral surface of the animal. Of these branches two are anterior; these are the pharyngeal commissures; the two others are posterior. Beside these branches, this ganglion furnishes a great number of nervous filaments, which detach themselves from it on all sides.

The two pharyngeal commissures proceed from the anterior extremity of the ganglion, at first diverging from it; but they soon proceed in a straight line and parallel to the head. They attach themselves strongly to the skin, are very flattened throughout their course, and become more and more narrow in proportion as they approach the head. When they reach it, each of them follows the lateral and upper insertion of the cephalic hood, creeping immediately under the skin; they form a kind of beautiful arcade, and after becoming extremely delicate, unite with the cephalic ganglion.

The two branches furnished by the posterior part of the ventral ganglion are larger, but shorter than the pharyngeal commissures, for they scarcely pass the first pair of fins; they also detach themselves from the ganglion, diverging from it, but soon take a parallel course backwards. At their posterior extremity they furnish a multitude of ramifications which at first remain at the side of one another, but subsequently exhibit greater divergence and assume something of the form of a horse-tail.

From the external margins of all the branches of the ventral ganglion a number of nerves separate; these ramifications, like those proceeding directly from the ventral ganglion, form all of them a curve on ascending toward the dorsal surface of the animal, and during their course become more and more divided, and furnish, by adhering and anastomosing, a fine and very complicated nervous network beneath the skin of the trunk.

Eyes.—We have already said that the optic nerves arise from the posterior cephalic nerves. Each optic nerve has its origin at the external margin of the branch which furnishes it; it then swells into a rounded ganglion, on which the eye is as it were set. The ganglion and the eye are placed in a peculiar closed cavity, hollowed in the skin of the head. The eye is much smaller than its ganglion; it is spherical, and enveloped in a pigment of a deep colour. When this eye is examined with the microscope there is

seen in one spot a spherical prominence, transparent as glass, and projecting beyond the pigmentary envelope; it is perhaps the cornea or the crystalline lens. At the circumference of the eye a very great number of short fibrils are perceived; in all probability these are fascicles of delicate nervous fibres which spring from the ganglion, and which seem to penetrate through the pigmentary envelope in the cavity of the eye.

Conclusions.—After having passed in review the structure of the *Sagitta*, we come at last to the question as to what place it should occupy in the animal series. MM. Quoy and Gaimard, who first noticed this animal, leave us in doubt on this point, and they admit that they did not sufficiently examine its structure to be able to pronounce an opinion. But even at present, when the organization of the *Sagitta* is better known, it is difficult to arrange it in a positive manner in any of the classes of our present systems. It is certain that the *Sagitta* is no mollusk; for although its nervous system seems organized on the general plan of these animals, most of the other parts of its organism and the habits of the animal do not seem to justify this affinity. In my opinion it can only be referred to the Annelides*. Here again great difficulties present themselves; for, not to mention the absence of rings, and taking only a small number of the peculiar characters of the *Sagitta*, where shall we find a genus of Annelides provided with a hood and a similar cephalic armature, fins, and so remarkable a disposition of the apparatus of generation? Nevertheless it seems evident to me that the *Sagitta* cannot enter into any other class than that of the Annelides, and that we must consider it as an anomalous genus, until we shall discover other animal forms which may connect it by gradual transitions of organization with some known genus of Annelides, or which shall completely separate it from this class of animals.

EXPLANATION OF PLATE IV. B.

In order not to encumber the figures with letters, we shall only indicate a single organ or a single half of an organ, when there is a pair of them. Figs. 3, 4, 5 and 6 represent the head magnified from ten to twelve times

* Having had occasion to observe the *Sagitta bipunctata* during my last voyage to Messina, I think I may say that I do not in any way share the opinion of M. Krohn on the natural affinities of that animal. I find nothing in its organization which can lead me to consider it as an Annelide, and I do not doubt that it is a mollusk, having in certain respects a great analogy to the *Firolæ*. It seems to me that the part designated by the author under the name of *head* is formed principally by the fleshy bulb of the mouth carrying the dental armature, and that it is the fold called hood in the preceding memoir which represents the head. The curious arrangement of the organs of generation noticed by M. Krohn constitutes the chief anomaly in the structure of this animal.—Milne Edwards.

as seen with a lens. The other figures are drawn from the organs seen under the microscope, and the determination of the magnifying power was made from the calculation of a vision of 7½ inches.

Fig. 1. The *Sagitta*, a little larger than its natural size,—a view of its dorsal surface: *a*, the head; *b*, first pair of lateral fins; *c*, second pair of lateral fins; *d*, caudal fin; *e*, openings of the excretory duct of the ovaries; *f*, prominence of the seminal cavities.

Fig. 2. The same animal—view of its ventral surface: *g*, ventral ganglion of the nervous system, seen by transmitted light; *h*, anterior branches of nerves, or pharyngeal commissures; *k*, posterior branches of nerves; *l*, the ovaries seen by transmitted light (they are here little developed); *m*, the anus.

Fig. 3. A view of the under-side of the head, with the hood in a state of complete expansion: *a*, the hood; *b*, inferior surface of the head; *c*, prominences furnished with bristles; *d*, the mouth; *e*, the hooks seen through the lateral parts of the hood: they are closed together; *f*, commencement of the trunk.

Fig. 4. Profile view of the head in a young specimen; the hood expanded: *a*, prominence on the upper surface of the head, beneath which is situated the right eye; *b*, the hooks of the right side in their state of repose; *c*, the trunk.

Fig. 5. Upper view of the head. The hood is retracted, and the hooks are in their state of erection: *a a*, superior and lateral points of insertion of the retracted hood; *b*, the free margin of the hood; *c*, the superior and lateral parts of the head and the hooks exposed; *d*, transparent view of the cephalic ganglion; *e*, the anterior cephalic nerves; *f*, the nervous loop formed by the posterior cephalic nerve; *g*, the eyes.

Fig. 6. Under view of the head, with the hood retracted and the hooks erect: *a a*, portion of the hood; *b*, the prominences furnished with bristles; *c*, the margin furnished with bristles; *d*, the mouth; *e*, the muscles of the hooks, forming a hemispherical projection.

Fig. 7. A ventral view of the posterior parts of the body, magnified five to six times, and turned so as to exhibit a larger portion of the left lateral surface: *a*, pair of posterior fins; *b*, caudal fin; *c*, anus; *d*, ovary seen by transmitted light, exhibiting the curve which it describes above; *e*, prominences of the seminal cells.

Fig. 8. Excretory apparatus of the seminal fluid; it is seen on two sides, magnified from ten to twelve diameters, and exposed as has been said in the text: *a*, the superior muscular band seen withinside; *b*, the two canals with their rounded apertures opening into the seminal cells; *c*, the cavities, the prominences of which are hollowed: at their bottom is seen the opening by which they communicate outwardly, in the form of a fissure.

Fig. 9. Excretory apparatus of the seminal fluid of the left side, more powerfully magnified: *a*, the canal; *b*, its opening, conducting into the seminal cells; *c*, cavity of the prominence; *d*, external opening visible on the sides of this cavity.

Fig. 10. An aggregation of cells (seminal globule), which is subsequently changed into spermatozoa (magnified more than seventy diameters).

Fig. 11. Indication of a very common state of development of the spermatozoa, and more advanced than the preceding; it is not mentioned in the text. In the centre are seen the cells of the primitive seminal globule diminished in volume (magnified ninety-five diameters).

Fig. 12. Mature spermatozoa, magnified 420 diameters.

Fig. 13. Systematic arrangement of the nervous system: *a*, cephalic ganglion; *b*, ventral ganglion; *c*, anterior branch of nerves or pharyngeal commissure; *d*, posterior branch; *e*, anterior cephalic nerves, with their ganglionic protuberances; *f*, *g*, posterior cephalic nerves describing a loop; *h*, optic nerves with their ganglions *k*.

Fig. 14. The eye, optic nerve and its ganglion, magnified ninety-five diameters: *a*, optic nerve; *b*, ganglion; *c*, eye; *d*, cornea or crystalline lens, forming a rounded prominence; *e*, fibrils visible toward the circumference of the eye; *f*, excavation in the skin of the head, in the interior of which the eye and the ganglion are inclosed.

XXXII.—*Descriptions of new or imperfectly described Diurnal Lepidoptera.* By Edward Doubleday, Esq., Assistant in the Zoological Department of the British Museum, F.L.S. &c.

[Continued from p. 236.]

Fam. PAPILIONIDÆ.

Genus Papilio.

The description of *P. Evan* given in the last Number had scarcely passed through the press, when the Museum received a large and valuable collection of insects from Sylhet, amongst which were specimens of this species, up to that time unique in Mr. Harrington's cabinet. One of these fortunately is a female, and I am therefore able to point out the characters in which this sex differs from the other. In size it is much larger, the expansion of the wings being full an inch and a half greater; the anterior wings are less falcate, their colour above much paler; the base is not shaded with fuscous, the spot on the disco-cellular nervule is more distinct, there are two or three irregular dark spots in the cell, the dark border is narrower and not quite of so deep a colour, the light fulvous spots are more distinct; the posterior wings are paler, the dark margin much narrower, the inner row of spots very distinct, the indentations and the tail pale fulvous, and the under surface is much paler.

In addition to some species described by Mr. Westwood not previously in the cabinets of the Museum, this collection contained a new species remarkable for the form of its posterior wings, and connecting *P. Protenor* and *Rhetenor* with *P. Ganesa*, *Bianor* and the other species of that group which have some of the nervules covered with down towards the extremities. For this species I propose the name of *P. Elephenor*, under which it will be found described below.

Whilst on the subject of the Indian *Papiliones*, I may remark upon an error in regard to three Indian species into which Erichson, in his Report on Entomology for 1842, has fallen. I have not troubled myself to do this so long as the report remained in